CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-57

December 1, 1977

1. Name of fault: Santa Susana fault.

2. Location of fault: Simi, Santa Susana, and Oat Mountain 7.5 minute quadrangles, Ventura and Los Angeles Counties (see figure 1). Note: the fault segment already zoned in the San Fernando quadrangle is not re-evaluated in this report.

3. Reason for evaluation: Part of a ten-year program.

4. List of references:

a) Bain, R.J., 1954, Geology of the Eureka Canyon area, Ventura County, California: Unpublished M.S. thesis, University of California, Los Angeles, map scale 1:12,000, 39 p.

b) Barnhart, J.T., and Slosson, J.E., 1973, The Northridge Hills and associated faults -- a zone of high seismic probability? in Geology, seismicity, and Environmental Impact: Association of Engineering Geologists, Special Publication, p. 253-256.

c) Barrows, A.G., Kahle, J.E., Saul, R.B., and Weber, F.H., Jr., 1974, Geologic map of the San Fernando earthquake area in San Fernando, California, earthquake of 9 February 1971: California Division of Mines and Geology, Bulletin 196, map scale 1:18,000.

d) Barrows, A.G., Kahle, J.E., Weber, F.H., Jr., Saul, R.B., and Morton, D.M., 1974, Surface effects map of the San Fernando earthquake area in San Fernando, California, earthquake of

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FIGURE 1. General location of the Santa Susana fault (Jennings, 1975, scale 1:750,000).

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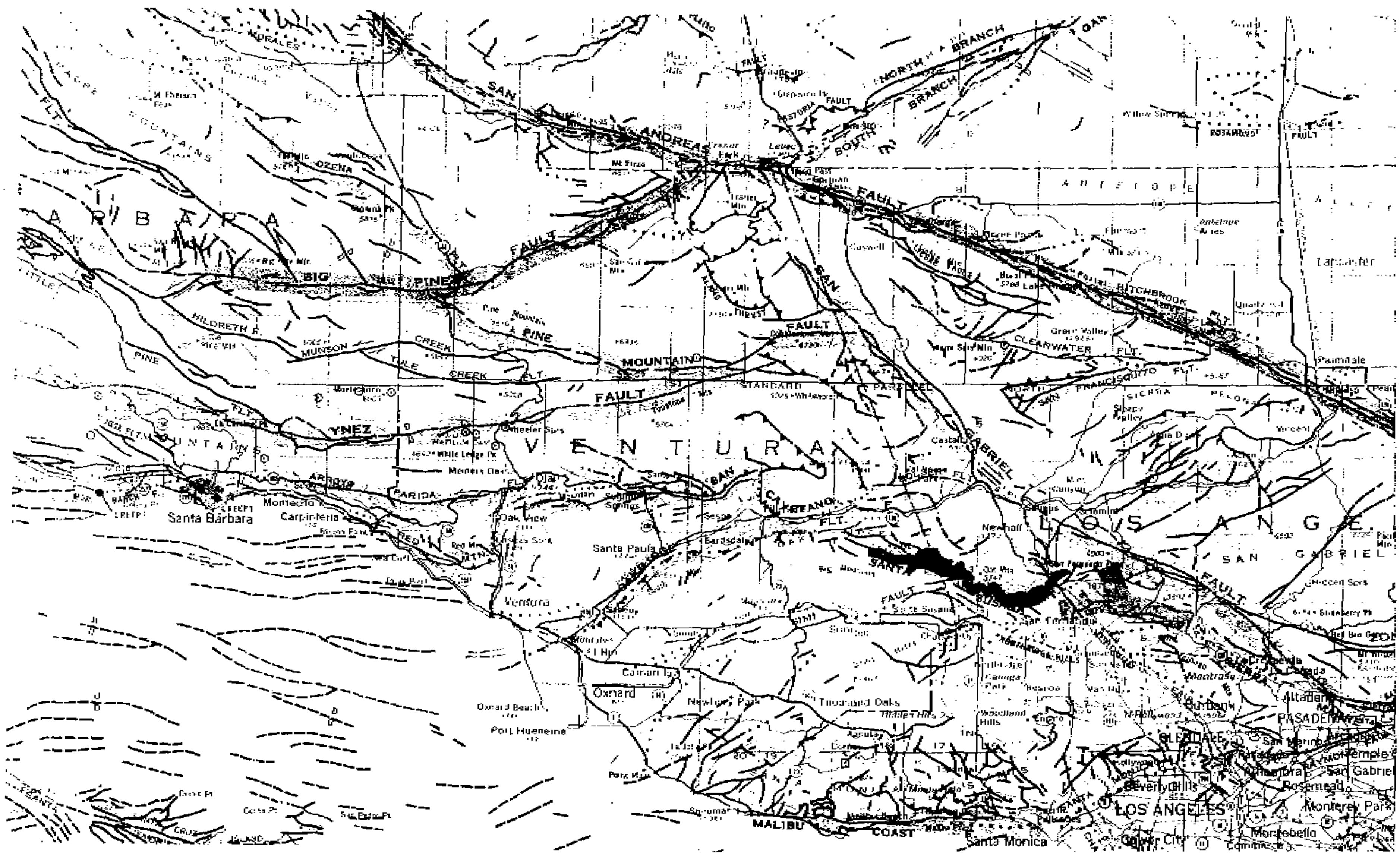

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9 February 1971: California Division of Mines and Geology, Bulletin 196, plate 3, scale 1:24,000.

e) Bishop, William C., 1950, Geology of the southern flank of Santa Susana Mountains, county line to Limekiln Canyon, Los Angeles County, California: Unpublished M.S. thesis, University of California, Los Angeles, map scale 1:24,000, 108 p.

f) Bonilla, M.G., Buchanan, J.M., Castle, R.O., Clark, M.M., Frizzell, V.A., Gulliver, R.M., Miller, F.K., Pinkerton, J.P., Ross, D.C., Sharp, R.V., Yerkes, R.F., and Ziony, J.I., 1971, Surface faulting <u>in</u> the San Fernando, California, earthquake of February 9, 1971: U.S. Geological Survey Professional Paper 733, p. 55-76.

g) Cabeen, W. R., 1939, Geology of the Aliso and Browns Canyons area, Santa Susana Mountains, California: Unpublished M.S. thesis, California Institute of Technology, geologic map on air photo (pages not numbered).

h) Evans, J.R., Unpublished map of the southwest quarter of the Oat Mountain quadrangle: California Division of Mines and Geology, scale 1:24,000.

i) Hazzard, J.C., 1944, Some features of the Santa Susana thrust, vicinity of Aliso Canyon field, Los Angeles County, California (abs.): Bulletin of the American Association of Petroleum Geologists, v. 28, p. 1780-1781.

j) Jennings, C.W., 1975, Fault Map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, scale 1:750,000.

k) Kew, W.S.W., 1924, Geology and Oil Resources of a part of Los Angeles and Ventura Counties, California, U.S.G.S. Bulletin 753, 202 p., 2 plates, map scale 1:62,500.

l) Leighton and Associates, Inc., 1977, Final technical report, geologic investigation by surface trenching of active (sic) faulting on the Santa Susana fault, Los Angeles and Ventura Counties, California: Unpublished consulting report conducted for the U.S. Geological Survey, contract number 14-08-0001-15863, 23 p., 5 appendices.

m) Lewis, William D., 1940, The geology of the upper Las Llajas Canyon area, California: Unpublished M.S. thesis, California Institute of Technology, 73 p., map on air photo.

n) Martin, D.R., 1958, Geology of the western part of the Santa Susana Mountains, Ventura County, California: Unpublished M.A. thesis, University of California, Los Angeles, map scales 1:12,000 and 1:24,000, 79 p.

o) Ricketts, E.W., and Whaley, K.R., 1975, Structure and stratigraphy of the Oak Ridge fault-Santa Susana fault intersection, Ventura basin, California: Unpublished M.S. thesis, Ohio University, 81 p., map scale 1:24,000.

p) Saul, R.B., in press, Unpublished mapping of the southeast quarter of the Oat Mountain quadrangle: California Division of Mines and Geology, map scale 1:9600.

q) Saul, R.B., 1975, Geology of the southeast slope of the Santa Susana Mountains and geologic effects of the San Fernando earthquake <u>in</u> San Fernando, California, earthquake of 9 February 1971: California Division of Mines and Geology, Bulletin 196, p. 53-70.

r) Van Camp, Q.R., 1959, Geology of the Big Mountain area, Santa Susana and Simi quadrangles, Ventura County, California: Unpublished M.A. thesis, University of California, Los Angeles, map scale 1:12,000, 98 p.

s) Weber, F.H., Jr., 1975, Surface effects and related geology of the San Fernando earthquake in the Sylmar area in San Fernando, California, earthquake of 9 February 1971: California Division of Mines and Geology Bulletin 196, p. 71-96.

t) Weber, F.H., Jr., Kiessling, E.W., Sprotte, E.C., Johnson, J.A., Sherburne, R.W., and Cleveland, G.B., 1975, Seismic hazards study of Ventura County, California: California Division of Mines and Geology, Open File Report 76-5LA, 396 p., 9 pl., map scale 1:48,000.

u) Wentworth, C.M., Bonilla, M.G., and Buchanan, J.M., 1969, Seismic environment of the Burro Flats site, Ventura County, California: U.S. Geological Survey open-file report 1973, 35 p., 2 figures, map scale 1:24,000.

v) Wentworth, C.M., and Yerkes, R.F., 1971, Geologic setting and activity of faults in the San Fernando area, California in The San Fernando, California earthquake of February 9, 1971: U.S. Geological Professional Paper 733, p. 6-16.

w) Winterer, Edward L., 1954, Geology of southeastern Ventura basin, Los Angeles County, California: Unpublished PhD. thesis, University of California, Los Angeles, 141 p., map scale 1:24,000.

x) Winterer, E.L., and Durham, D.L., 1962, Geology of southeastern Ventura Basin, Los Angeles County, California: U.S. Geological Survey Professional Paper 334-H, p. 275-366, map scale 1:24,000.

y) Ziony, J.I., Wentworth, C.M., Buchanan-Banks, J.M., and Wagner, H.C., 1974, Preliminary map showing recency of faulting in coastal southern California: U.S. Geological Survey, Miscellaneous Field Studies MF-585, 15 p., map scale 1:250,000, 3 plates.

5. Summary of available data:

The Santa Susana fault is generally regarded as a north-dipping thrust fault which is locally horizontal or even south dipping, at least near the surface (Winterer, 1954, and many others). At depth, the fault dips steeply northward (Winterer, 1954). Thus, the fault presents a rather sinuous, surface trace (see plate 1).

Hazzard (1944, p. 1780-1781) described the fault as near vertical at depths of 6900 feet below sea level, but flattening out nearer the surface. Hazzard estimated that the total displacement along the fault is in excess of 2480 meters. Saul (1975, p. 61) suggests 1860 meters of displacement since the deposition of the Modelo Formation (late Miocene). This yields a displacement rate of about 0.2 mm per year, or 2 m. every 10,000 years.

The eastern segment of the Santa Susana fault is already zoned for special studies based on the 1971 San Fernando earthquake (plates 2 and 3). Weber (1975, p. 72) notes, "The trace of the lower (Santa Susana) fault ... was clearly expressed by the effects of the earthquake." He cites small left-lateral and reverse displacements along the Santa Susana.

Saul (1975, p. 53, 56-66), although he notes a one foot left-lateral displacement in 1971 along the Santa Susana, stated "Most of the surface breaks ... were confined to a zone along the trace of the

Santa Susana thrust, probably as a result of local amplification of ground shaking" (and not of faulting). Thus, Saul (p. 69-70) concludes that the Santa Susana fault is an "older, probably inactive fault" that "has been inactive since the middle Pleistocene." I believe that Saul is attempting to state his belief that the Santa Susana fault has not been the site of recent fault rupture resulting from release of stress across the Santa Susana; or putting it another way, had there not been a major earthquake in the area on another fault, no displacement along the Santa Susana would have occurred -- no stress is being accumulated across the fault (although I have reservations about such a conclusion ~~this~~).

Bonilla, et al. (1971, p. 75) reported that the Santa Susana fault was checked (the location was not noted) and that no movement occurred on the fault during and immediately following the San Fernando event. In contrast, Meehan (1971, p. 241) cites movement on the Santa Susana fault beneath a highway overpass as the possible reason for the collapse of overpass.

Ziony, et al. (1974), depict the Santa Susana fault as cutting nothing younger than a Plio-Pleistocene unit. However, most authors believe that the Santa Susana fault displaces terrace deposits of probable late Pleistocene age (Weber, 1975, p. 71; Hazzard, 1944, p. 1781; Cabeen, 1939, p. 30; Lewis, 1940, p. 48; Van Camp, 1959, p. 73; Winterer and Durham, 1962, p. 335; Wentworth, et al., 1969, p. 15; Wentworth and Yerkes, 1971, p. 12; Martin, 1958, p. 57; and Weber, et al., 1975, p. 192-195) (see plate 1 for specific locations). Weber, et al. (1975), in two photos and one figure, show the fault overriding terrace deposits (figures 2, 3, and 4). Saul (1975, p. 61)

FER57, Figure 2.
(From Weber, et al (1975)).

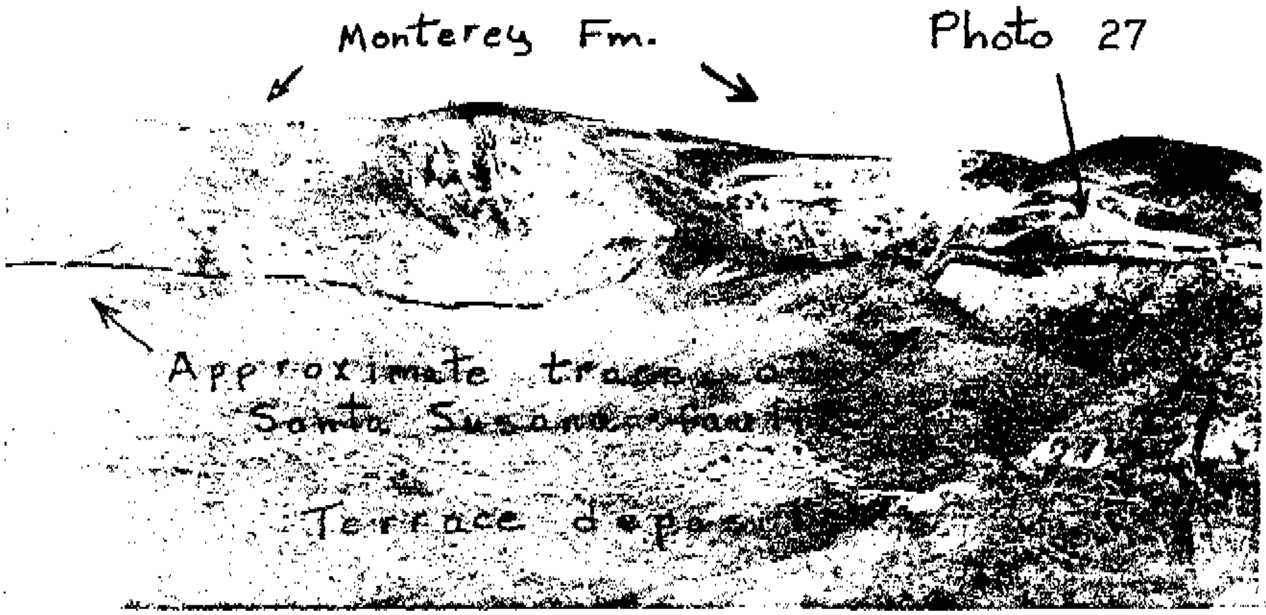

Photo 26. View north in northern Tapo Canyon area. Principal strand of north-dipping Santa Susana fault zone extends approximately along principal break in terrain between subdued, terraced topography of foreground, as opposed to hilly, Oak Ridge in background. Silicified shale of Monterey/Modelo Formation making up portion of Oak Ridge shown is thrust south relatively over older alluvium/terrace deposits of late Quaternary age of foreground.

FER 57, Figure 3.
(From Weber, et al. 1975)

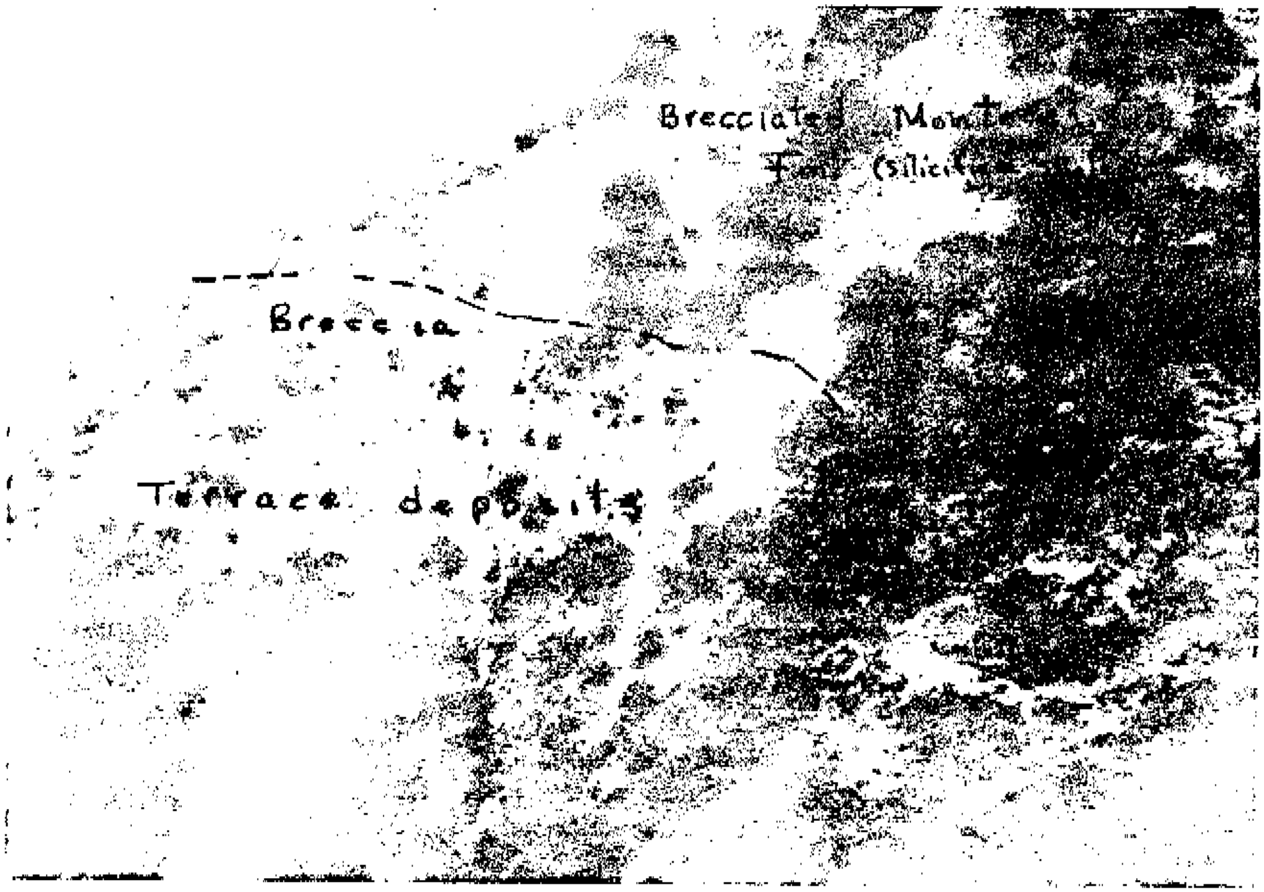

Photo 27. View west from 50 to 100 feet away shows subtle exposure of principal strand of Santa Susana fault in upper Tapo Canyon area north of Simi Valley. Fault dips about 15° north. Fractured, partially silicified shale of Monterey/Modelo Formation is thrust south over older alluvium of late Quaternary age. This alluvium is composed mostly of crudely bedded, fine to medium-grained chips of silicified shale which are similar to the faulted, overlying bedrock; in addition, the attitude of both rocks in the vicinity of the fault is similar to that of the fault, hence the subtle nature of the exposure of the fault. Youthful geomorphic features are not common along the fault in this vicinity, but geologic features, together with uncommon geomorphic features, suggest that the fault is potentially active. See Figure 13.

FER 57, Figure 4.
(From Weber, et al 1975).

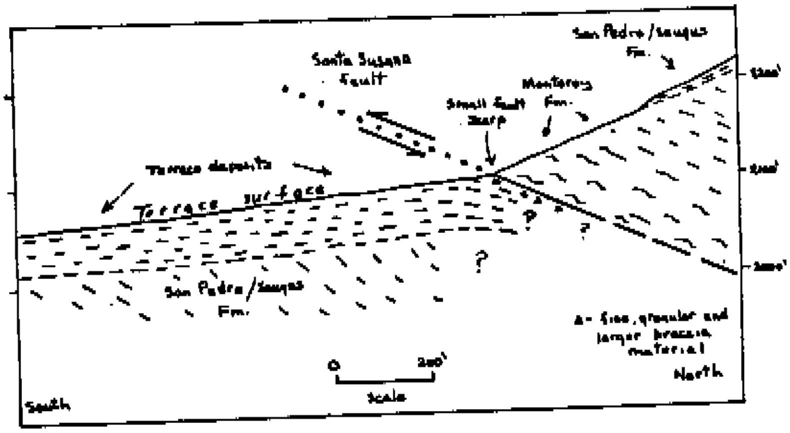

Figure 13. Generalized cross section, north Tapo Canyon area, north of Simi Valley, shows late Quaternary terrace deposits and overlying erosional surface being overridden by siliceous shale of Monterey Formation of middle - late Miocene age. Note how faulting has caused the terrace deposits to bend under the fault.

disagrees and states that these units, where they are exposed in Los Angeles County (he doesn't know the age of the units cited as offset in Ventura County - p.c., 1977), are part of the Saugus Formation, and are no younger than mid-Pleistocene.

The Santa Susana fault is largely obscured by landslides (Bishop, 1950, plate 1; and many others). This is to be expected of active thrust faults because of the sheared bedrock and the increased relief caused by uplift along the fault. However, coupled with the sinuous trace of the fault, the landslides may make it difficult to find the fault. I suspect also that the bedrock is much more sheared, and the geology more complex than the two or three strands shown by many authors. Indeed, Hazzard (1944, p. 1780) notes an "extensive shear zone" below the main fault trace.

In 1977, Leighton and Associates trenched across part of the Santa Susana fault zone in two areas, one near Topo Canyon and one near Horse Flats (see plate 1). A series of 28 trenches were cut, 17 at Porter Ranch (near Horse Flats) and 11 at Tapo Canyon (Leighton and Associates, 1977, p. 9). The trenches at Porter Ranch failed to intersect the south branch of the fault; however, Leighton and Associates felt that they were able to pinpoint a 175 foot wide area as the probable location of the fault. They noted the presence of "minor faults within the terrace deposits, generally parallel to the main fault trace" within a road-cut near the site. They were unable to find any datable materials at this site (Leighton and Associates, 1977, p. 16-17). Also, they believe that possibility of dating (empirically or directly) the age of most recent movement of the north branch is impossible in this area.

The T~~o~~apo Canyon site proved more fruitful (Leighton and Associates, 1977, p. 11-13, 16-17, plate 8). In trench T-1, 5 faults were exposed. Four of these appear (on their log) to cut terrace deposits; however, these faults do not cut younger fanglomerate. No evidence of faulting south of these traces was found. A carbon sample taken 2,000 feet west of T-1, from trench T-2 was dated at 10,0~~0~~10± 580 y.b.p. This sample was obtained from an alluvial deposit which is inferred to overlie the fault (which was not exposed in the trenches at a depth of 15 feet).

Leighton and Associates (1977, p. 11) qualify their data noting that a recently active fault trace might be located north of (their trench) T-1. They state that such faults "could easily go undetected," since they would probably manifest themselves as bedding plane faults within the Modelo Formation.

Leighton and Associates (1977, p. 19) note that the fault zone, as mapped, ranges from 1/4 to 1 1/2 km in width, partly because of the low angle of dip. They also note that massive landslides often obscure the trace of the fault.

Leighton and Asoociates (1977, p. 20) note:

> "Proving that the Santa Susana fault (zone) is inactive does not appear to be a likely outcome of any fault activity investigation in the near future. Even though individual fault traces may prove to be inactive, it will be extremely difficult to preclude with absolute certainty the possibility of an undetected trace, or that a known trace has not had displacement within Holocene time."
>
> "The fault does not appear to be particularly amiable to a conclusive determination of its activity state by trenching of any single fault trace because of the complexity of the zone and the lack of suitable trenching sites. This is in contrast, perhaps, to other major faults that are comparatively well-defined and limited to one, or perhaps two, distinct traces, and where there is a greater opportunity to determine their relationship with the younger surficial deposits by means of trenching."

6. Air photo Interpretation:

Cursory examination of air photos suggests that the fault could be late Quaternary in age, based on the amount of relief, changes in slope, etc. Detailed air photo interpretation could be beneficial, and may provide data as to which fault segments are most likely to be the most recently active.

7. Field observations: Not attempted.

8. Conclusions:

The Santa Susana thrust is probably a late Quaternary fault (item 5). Local ground breakage along easternmost segment of the fault (already zoned) during 1971 suggest that the fault may be active. To date, however, Holocene displacement has not been documented on any segments other than the one already zoned. Indeed, Leighton and Associates (1977) has demonstrated that one of the late Quaternary traces is probably not Holocene in age.

The most recently-active branches of the fault may be difficult to locate because of the extensive landsliding and the generally sheared nature of the bedrock. It is possible that relatively young, datable units may be lacking or are not recognized along the most recently-active traces. While no definite conclusion can be drawn with respect to the relative definition of the fault at all sites, it is quite possible, even probable that many segments of the fault will be ill-defined. More work is necessary to determine which segments, if any, are well-defined and Holocene.

9. Recommendations:

Based on the data contained herein and the present project guidelines, further zoning of the Santa Susana fault is not recommended at this time. Because of the historic displacement along part of the fault, and the overthrust terrace deposits present, it is recommended that further study -- both air photo interpretation and field checking -- be conducted in the near future. Since most of the fault lies within five miles of the greater Los Angeles metropolitan area, this investigation should be assigned a relatively high priority.

10. Investigating geologist's name; date:

Theodore C. Smith

Theodore C. Smith
Assistant Geologist
December 1, 1977

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I agree with the tentative recommendation not to zone. However, I would feel more confident if key localities were field checked. Airphoto interpretation should be very limited, if used at all, because of time constraints and ~~sty~~ style of faulting. Also, please field check a few 1971 breaks to see if there is evidence of repeated recent offset in the geomorphic features.

EWHart
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